

**EXHIBIT A**

**LEGAL ID#**

9187

ANG/DIND/BAD

DATE:

**March 8, 1998**

**MAR 12 1998**

**It is important to provide accurate and detailed information on this form. The information will be used to evaluate your invention for possible filing as a patent application. When completed, please return this form to the Legal Department at JF3-147. If you have any questions, please call 264-0444 or 264-0998.**

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 Citizenship: USA      BUM Presenter: Don Whiteside  
 Group: (e.g. TMG, ICG, CEG) DIVD      Division Name \_\_\_\_\_      Subdivision B&AD  
 Supervisor\* Peter Green      WWID 10031116      Phone 602-554-2236      M/S: CH6-405

✓ Inventor: Connolly Kevin M  
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Group: (e.g. TMG, ICG, CEG) DIVD Division Name \_\_\_\_\_ Subdivision ITM  
Supervisor\* Bob Sundahl WWID 10047471 Phone 602-554-5679 M/S: CH6-438  
(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

**2. Title of Invention:** Integrated Sensing and Local Storage for 3-Color-Plane Capture: Architecture #2

3. What technology/product/process (code name) does it relate to: Focal-Plane Processing, Diode On Top (DOT) Technology, Digital Cameras

4. Stage of development (i.e. % complete) \_\_\_\_\_ Research Phase \_\_\_\_\_

**5. (a) Has a description of your invention been, or will it shortly be, published outside Intel:**

NO:   X   YES:            DATE WAS OR WILL BE PUBLISHED:             
If YES, was the manuscript submitted for pre-publication approval? YES:            NO:           

**(b) Has your invention been used/sold or planned to be used/sold by Intel or others?**

NO: ☒ YES: ☐ DATE WAS OR WILL BE SOLD: Possible not currently in plan

(c) Does this invention relate to technology that is or will be covered by a SIG (specification)?

NO: ☒ YES: ☐ Name of SIG/Standard/Specification: \_\_\_\_\_

(d) If the invention is a semiconductor device, actual or anticipated date of tapeout? Q3 98

(e) If the invention is software, actual or anticipated date of any beta tests. \_\_\_\_\_

6. Was the invention conceived or constructed in collaboration with anyone other than an Intel blue badge employee or in performance of a project involving entities other than Intel, e.g. government, other companies, universities or consortia?

NO: ☒ YES: ☐ Name of individual or entity: \_\_\_\_\_

**PLEASE READ AND FOLLOW THE DIRECTIONS ON THE ATTACHED PAGE ON HOW TO WRITE A DESCRIPTION OF YOUR INVENTION**

Please attach a page to this form, DATED AND SIGNED BY AT LEAST ONE PERSON WHO IS NOT A NAMED INVENTOR, to provide a description of the invention, and include the following information:

1. Describe in detail how the invention works.
2. Describe advantage(s) of your invention over what is done now.
3. Include at least one figure illustrating the invention. If the invention relates to software, include a flowchart or pseudo-code representation of the algorithm.
4. Value of your invention to Intel (how will it be used?).
5. Identify the closest or most pertinent prior art that you are aware of.
6. Who is likely to want to use this invention or infringe the patent if one is obtained and how would infringement be detected?

\*HAVE YOUR SUPERVISOR READ, DATE AND SIGN COMPLETED FORM

DATE: 3/10/98

SUPERVISOR: \_\_\_\_\_



BY THIS SIGNING, I (SUPERVISOR) ACKNOWLEDGE THAT I HAVE READ AND UNDERSTAND THIS DISCLOSURE, AND RECOMMEND THAT THE HONORARIUM BE PAID

## Title:

Integrated Sensing and Local Storage for 3-Color-Plane Capture: Architecture #2

## Description:

This architecture combines the use of a programmable color filter array, local analog-to-digital conversion within each pixel of a CMOS sensor array, and two bytes of local digital storage within each pixel. The color filter array must be such that each of three colors is filtered at three separate times (occurring very quickly in succession), while allowing capture of each color plane at all pixel locations within the sensor array. The primary motivation for this method is to improve image quality by eliminating any need for color interpolation, which is required for the color mosaic patterns currently used in digital capture systems. This particular architecture describes the additional components necessary for (1) local analog-to-digital conversion and (2) local digital storage of two bytes. The sequencing to perform the capture of three-separate color planes with this architecture is also an important contribution of this disclosure.

## General Purpose of Invention:

The purpose of this invention is to create a higher quality color image by using the extra area available for storage when amorphous silicon photodiodes are placed on top of the silicon processing layers (Diode on Top, or DOT technology) in CMOS sensor devices. The invention requires the use of a color filter that covers the entire sensor array area and can be switched from one band of wavelengths to the next. This particular architecture integrates the photocurrent of the diodes for each color plane and converts each of these analog values to 8-bit digital values that can be stored locally. The local storage is necessary to ensure proper sequencing of the data coming off the chip. In this way the data is formatted into 8-bit words and scanned off in 8-bit packets from each pixel, instead of breaking each color plane into 8 bit-planes (the result of the operation of the ADC, which only produces a single bit output at a time.) The first color byte would go into first register. The second color byte would go in the second register while the first register (first color plane) is being read. The third color byte would then go into the first register. The 2 bytes of storage could also be used to store only the first two color planes, and the third color plane would be read off as the 8 bit-planes; this would avoid having to read out digital values while doing any of the analog processing.

## Advantages over current methods:

The advantage of this invention is improved color quality for digital capture and the elimination of the need for color interpolation processing to produce full 24-bit RGB images. Another advantage of this invention is the creation of separate color planes, which could be used in focal-plane processing systems that perform more advanced image processing operations in a fully parallel architecture. The elimination of a color mosaic pattern ensures that neighboring pixels (within each color plane) have a high degree of correlation, due to the spatial redundancies in natural images. Thus, the communication in these types of systems becomes much more local and regular. The specific benefits of this architecture are that the local storage enables the formatting of the digital information into 8-bit words, thus ensuring that the data does not have to undergo additional manipulation off-chip.

## Essential elements of invention:

The essential elements of the invention are:

1. CMOS sensor array with DOT technology
2. Electronically programmable color filter
3. Active pixel circuitry for integration of photocurrent
4. Local ADC
5. Two bytes of digital storage (static or dynamic RAM)

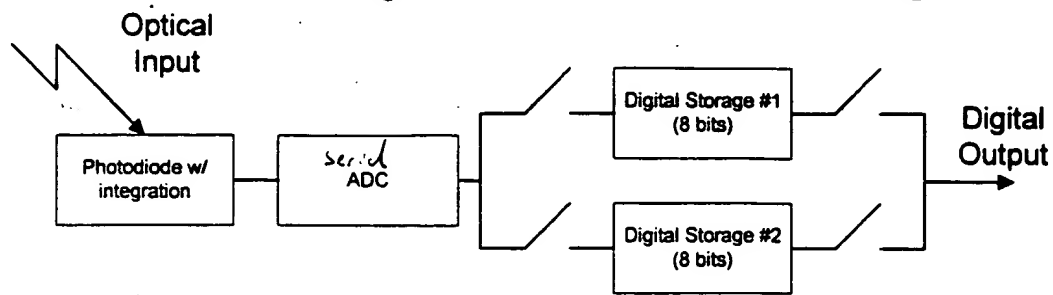
## Value of invention to Intel:

The ability to capture high resolution color planes is important to the continued improvement of digital cameras. This ability also leads into potential focal-plane processing applications that can take advantage of the ability to process the color planes separately, using highly regular local connections.

*Read and Understood:*

*Lawrence A. Berth, Jr.*

*Mar 10, 1998*



Block Diagram of Pixel Components

## INTEL INVENTION DISCLOSURE

LEGAL ID#

9188

ANG/DIVD/BAD

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 Supervisor\* Peter Green WWID 10031116 Phone 602-554-2236 M/S: CH6-405

Intel 554-8080

2. Inventor: Connolly Kevin M  
 Last Name First Name Middle Initial  
 SS# 141-60-7698 WWID 10532526 Phone 602-554-9170 M/S: CH6-438  
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 Supervisor\* Bob Sundahl WWID 10047471 Phone 602-554-5679 M/S: CH6-438

(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

2. Title of Invention: Integrated Sensing and Local Storage for 3-Color-Plane Capture: Architecture #1

3. What technology/product/process (code name) does it relate to: Focal-Plane Processing, Diode On Top (DOT) Technology, Digital Cameras

4. Stage of development (i.e. % complete) Research Phase

5. (a) Has a description of your invention been, or will it shortly be, published outside Intel:

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NO: X YES: DATE WAS OR WILL BE PUBLISHED:

If YES, was the manuscript submitted for pre-publication approval? YES: NO: MAR 17 1998

(b) Has your invention been used/sold or planned to be used/sold by Intel or others?

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NO: X YES: Name of SIG/Standard/Specification:

(d) If the invention is a semiconductor device, actual or anticipated date of tapeout? Q3 98

(e) If the invention is software, actual or anticipated date of any beta tests.

6. Was the invention conceived or constructed in collaboration with anyone other than an Intel blue badge employee or in performance of a project involving entities other than Intel, e.g. government, other companies, universities or consortia?

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2. Describe advantage(s) of your invention over what is done now.
3. Include at least one figure illustrating the invention. If the invention relates to software, include a flowchart or pseudo-code representation of the algorithm.
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SUPERVISOR: \_\_\_\_\_



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## Title:

Integrated Sensing and Local Storage for 3-Color-Plane Capture: Architecture #1

## Description:

This architecture combines the use of a programmable color filter array, local storage of three color planes within each pixel of a CMOS sensor array, and local analog-to-digital conversion within each pixel. The color filter array must be such that each of three colors is filtered at three separate times (occurring very quickly in succession), while allowing capture of each color plane at all pixel locations within the sensor array. The primary motivation for this method is to improve image quality by eliminating any need for color interpolation, which is required for the color mosaic patterns currently used in digital capture systems. This particular architecture describes the additional components necessary for (1) local analog storage of these three color planes and (2) local analog-to-digital conversion.

## General Purpose of Invention:

The purpose of this invention is to create a higher quality color image by using the extra area available for storage when amorphous silicon photodiodes are placed on top of the silicon processing layers (Diode on Top, or DOT technology) in CMOS sensor devices. The invention requires the use of a color filter that covers the entire sensor array area and can be switched from one band of wavelengths to the next. This particular architecture integrates the photocurrent of the diodes for each color plane and stores each analog voltage on a storage capacitor. A local analog-to-digital converter (ADC) is used to pass the three color values as three bytes of data. The fully parallel ADC units (one in each pixel, or group of pixels) ensure high-speed conversion, and the digital transmission ensures high precision outputs from this large array of 3-byte pixel values.

## Advantages over current methods:

The advantage of this invention is improved color quality for digital capture and the elimination of the need for color interpolation processing to produce full 24-bit RGB images. Another advantage of this invention is the creation of separate color planes, which could be used in focal-plane processing systems that perform more advanced image processing operations in a fully parallel architecture. The elimination of a color mosaic pattern ensures that neighboring pixels (within each color plane) have a high degree of correlation, due to the spatial redundancies in natural images. Thus, the communication in these types of systems becomes much more local and regular. The specific benefits of this architecture are that the analog storage does not require much area and the local ADC ensures high-speed transfer of data with high precision.

## Essential elements of invention:

The essential elements of the invention are:

1. CMOS sensor array with DOT technology
2. Electronically programmable color filter
3. Active pixel circuitry for integration of photocurrent
4. Three local analog storage capacitors and multiplexing circuits
5. Local ADC

## Value of invention to Intel:

The ability to capture high resolution color planes is important to the continued improvement of digital cameras. This ability also leads into potential focal-plane processing applications that can take advantage of the ability to process the color planes separately, using highly regular local connections.

## Related cases:

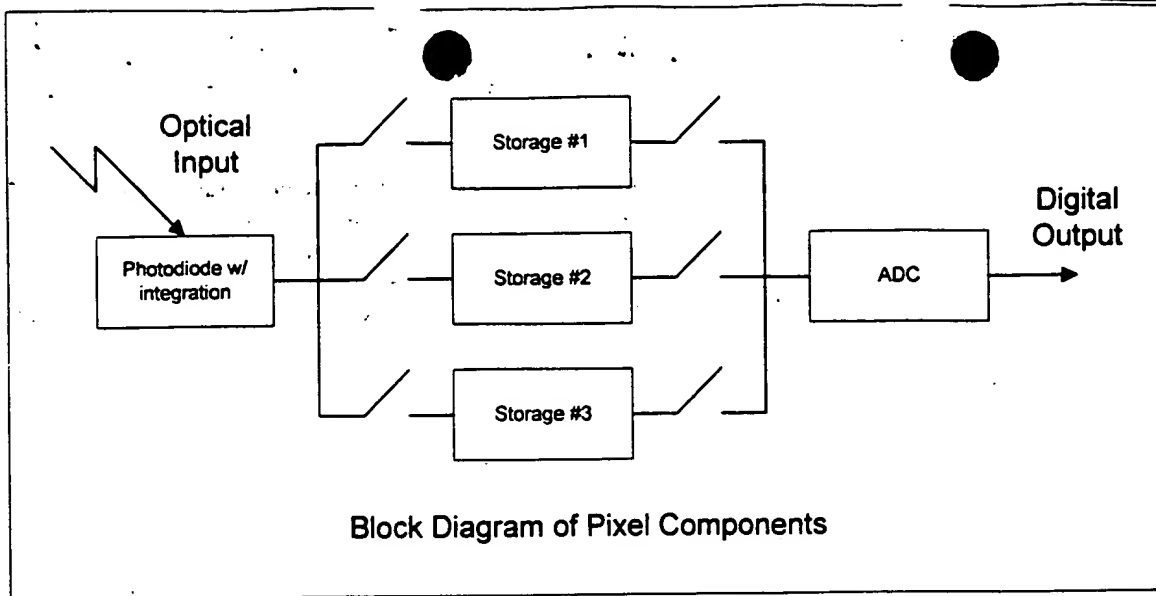
"Active Pixel CMOS Sensor with multiple Storage capacitors," submitted by Lawrence A. Booth, Jr.

*read and understood*

*[Signature]*  
Lawrence A. Booth, Jr.

*7069*  
*2660*  
Mar 10, 1998





## TEL INVENTION DISCLOSURE

LEGAL ID#

9186

TMG/DIVD/BAD

DATE: March 8, 1998 MAR 12 1998

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 Supervisor Bob Sundahl WWID 10047471 Phone 602-554-5679 M/S: CH6-438

(PROVIDE SAME INFORMATION AS ABOVE FOR EACH ADDITIONAL INVENTOR)

3. Title of Invention: Integrated Sensing and Local Storage for 3-Color-Plane Capture: Architecture #3

4. What technology/product/process (code name) does it relate to: Focal-Plane Processing, Diode On Top (DOT) Technology, Digital Cameras

5. Stage of development (i.e. % complete) Research Phase

6. (a) Has a description of your invention been, or will it shortly be, published outside Intel:

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(d) If the invention is a semiconductor device, actual or anticipated date of tapeout? Q3 98

(e) If the invention is software, actual or anticipated date of any beta tests. \_\_\_\_\_

7. Was the invention conceived or constructed in collaboration with anyone other than an Intel blue badge employee or in performance of a project involving entities other than Intel, e.g. government, other companies, universities or consortia?

NO: X YES: \_\_\_\_\_ Name of individual or entity: \_\_\_\_\_

MAR 17 1998

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## Title:

Integrated Sensing and Local Storage for Color-Plane Capture: Architecture #3

## Description:

This architecture combines the use of a programmable color filter array, local analog-to-digital conversion within each pixel of a CMOS sensor array, and three bytes of local digital storage within each pixel. The color filter array must be such that each of three colors is filtered at three separate times (occurring very quickly in succession), while allowing capture of each color plane at all pixel locations within the sensor array. The primary motivation for this method is to improve image quality by eliminating any need for color interpolation, which is required for the color mosaic patterns currently used in digital capture systems. This particular architecture describes the additional components necessary for (1) local analog-to-digital conversion and (2) local digital storage of three bytes. The sequencing to perform the capture of three separate color planes with this architecture is also an important contribution of this disclosure.

## General Purpose of Invention:

The purpose of this invention is to create a higher quality color image by using the extra area available for storage when amorphous silicon photodiodes are placed on top of the silicon processing layers (Diode on Top, or DOT technology) in CMOS sensor devices. The invention requires the use of a color filter that covers the entire sensor array area and can be switched from one band of wavelengths to the next. This particular architecture integrates the photocurrent of the diodes for each color plane and converts each of these analog values to 8-bit digital values that can be stored locally. The local storage is necessary to ensure proper sequencing of the data coming off the chip. In this way the data is formatted into 8-bit words and scanned off in 8-bit packets from each pixel, instead of breaking each color plane into 8 bit-planes (the result of the operation of the ADC, which only produces a single bit output at a time.) In this architecture each of the three colors can be stored in its own 8-bit local storage register. With this architecture, the scanning can be delayed until all 3 color planes have been captured and converted. The output is in the format of a 24-bit RGB image.

## Advantages over current methods:

The advantage of this invention is improved color quality for digital capture and the elimination of the need for color interpolation processing to produce full 24-bit RGB images. Another advantage of this invention is the creation of separate color planes, which could be used in focal-plane processing systems that perform more advanced image processing operations in a fully parallel architecture. The elimination of a color mosaic pattern ensures that neighboring pixels (within each color plane) have a high degree of correlation, due to the spatial redundancies in natural images. Thus, the communication in these types of systems becomes much more local and regular. The specific benefits of this architecture are that the local storage enables the formatting of the digital information into 8-bit words without having to scan data between color planes, thus ensuring that the data is in a 24-bit RGB format.

## Essential elements of invention:

The essential elements of the invention are:

1. CMOS sensor array with DOT technology
2. Electronically programmable color filter
3. Active pixel circuitry for integration of photocurrent
4. Local ADC
5. Three bytes of digital storage (static or dynamic RAM)

## Value of invention to Intel:

The ability to capture high resolution color planes is important to the continued improvement of digital cameras. This ability also leads into potential focal-plane processing applications that can take advantage of the ability to process the color planes separately, using highly regular local connections.

*Read and Understood:*

*Lawrence A. Bata, Jr*

*Nov 10, 1998*